WHITE TERNS ON OAHU PRODUCE SIBLINGS FIVE MONTHS APART

DOROTHY H. MILES, 2957 Kalakaua Avenue, Apt. 116, Honolulu, Oahu, Hawaii 96815

White Terns (*Gygis alba*) commonly breed on remote atolls and islands in tropical and subtropical regions, including the Northwestern Hawaiian Islands (NWHI). In 1961 a pair of these seabirds was reported to be breeding at Koko Head on Oahu (Ord 1961), the only main Hawaiian Island where they have been found. Since then the terns have expanded their nesting area some 16 km to the civic center of Honolulu. Harrison et al. (1984) estimated 50-100 pairs in the main Hawaiian Islands.

Dorward (1963) found that the White Tern was one of the few species on Ascension Island to have a distinct annual breeding season, laying about January. Individual pairs laid on the same ledge in successive seasons with an interval of close to a year. On Christmas Island in the Central Pacific Ocean Ashmole (1968) found that incubation and chick-rearing took about 5 months and molt about 5.5 to 7 months. Howell (1978) found the incubation period to be 35 days. Pettit et al. (1981) found the White Tern to be one of only two terns with prolonged incubation and to have the longest incubation in relation to its egg mass of any tern. A single egg is laid but no nest is built.

Here I present the results of my study of White Tern breeding biology on Oahu. I describe differences occurring in individual breeding pairs; these previously undescribed differences concern the lengths of intervals between breeding which, in turn, affect the number of offspring produced in one year.

STUDY AREA AND METHODS

The breeding area of the first pair of White Terns to exhibit an unusual breeding pattern (Pair 1 in 1979) became the focal point of a 6-year study. This small nesting area was located in Kapiolani Park on the south shore of the Island of Oahu between Diamond Head crater and the Pacific Ocean. The 45 m x 90 m area contained 13 ironwood (*Casuarina equisetifolia*) trees spaced 3.6 m to 5.4 m apart and surrounding a central open space. In 1982 this nesting area was extended to include a nearby Kiawe (*Prosopis pallida*) tree. A row of high-rise oceanfront condominiums served as a protective barrier. This urban park environment had traffic on three sides and other human activity in the area. Several species of introduced land birds and escaped cage birds competed for nesting trees but no other White Terns bred there.

The focal area was one of 16 White Tern breeding areas which I monitored in Kapiolani Park (1975-1984). Breeding here was discovered in October 1970 (Berger 1981). The 68 ha park extends about 1 km from Diamond Head to Waikiki parallel to the shoreline. The park has a central athletic field and numerous picnic areas which receive much human use. In addition to the ironwood from Australia, many large, old trees introduced from Asia and Africa offer the White Terns ample choices of nest sites. I recorded 56 nest sites in 14 species of trees. Breeding pairs sought isolation; distances between

nests were always greater than 10 m. I generally made daily observations for periods ranging from a few minutes' check to more than 8 hours. Night observations of sleeping perches in the focal area were made to help determine the identity of individuals remaining in the area. Some terns arrived on their perches after dark and left before dawn; therefore, periodic night checks also assured more accurate data on population size.

Beginning in May 1981 chicks were banded at about 5 weeks of age with both a numbered anodized aluminum band and a color-coded plastic band. Moynihan (1962), while studying White Terns on Moto Nui Islet off Easter Island, noted that each bird selected a station on which it perched most of the time. Consistent use of one perch by an unbanded bird during a breeding season and in subsequent seasons provided strong evidence of its identity. The terns' attachment to a particular perch and to their chosen nest sites, along with slight variations in physical appearance as well as differences in behavior and vocalizations, made individual identification possible. The sex of breeding partners was determined during observations of courting and copulation. Howell (1978) noted that in birds marked before the egg-laying stage he could usually tell by subsequent behavior which was male and which female.

Chicks that hatched before 1981, including the first four offspring of Pair 1, were not banded. Nevertheless after 6 years of daily observations of this isolated pair and their extended family, I am convinced that I was observing the same individuals.

RESULTS

Most pairs of White Terns initiated nesting activity in January or February, reared a single chick and were gone by November. However, some pairs (hereafter called short-cycle breeders) laid again after rearing a chick and hatched second or third chicks. These pairs did not leave the area when annual breeders left if they were courting again, incubating an egg or rearing a chick. The percentage of short-cycle breeders increased from 20% in 1979 (1 of 5 pairs) to 37% in 1984 (11 of 28 pairs monitored that year). In 1980 the nest limb of a pair of short-cycle breeders was cut off by tree-trimmers and, therefore, lost to my study. By August 1984 12 pairs had produced offspring on a short breeding cycle in Kapiolani Park. A pair nesting on private property at Diamond Head reared one chick in 1983 and was discovered to be a short-cycle breeder in 1984, bringing the total known on Oahu to 13 pairs.

Relationship Between Three Pairs

In 1978 Pair 1 established a new breeding area. An infertile egg was laid on 8 June, incubated for 126 days and abandoned on 12 October when the pair left the area. In January 1979 Pair 1 returned to the same nest and reared two chicks 5 months apart. These two 1979 siblings (hereafter called Pair 2) mated and began breeding in February 1981 at ages 18 and 23 months. In 1980 Pair 1 reared two more siblings 5 months apart. The two 1980 siblings (hereafter called Pair 3) began breeding in December 1981 at ages 16 and 21 months. Pair 2 and Pair 3 remained in their natal area and

also bred at short intervals; they produced nine third-generation chicks during the same period (1981-1984) that their parents (Pair 1) reared seven additional offspring.

Intervals Between Egg-Laying for Three Related Pairs

Between June 1978 and December 1984 pairs 1, 2 and 3 laid 24 eggs and produced 20 offspring in the focal area. Intervals between egg-laying are shown in Table 1.

I found five other short-cycle breeding pairs in five different areas, one in 1980 and four in 1983. Two of these pairs had been recorded as annual breeders because they had reared a single chick during the previous year. In 1984 I discovered that four more pairs of annual breeders had laid at short intervals and produced chicks. Therefore, a total of six pairs changed their

Table 1. Dates of egg laying, approximate intervals between eggs laid, and number of eggs laid and chicks fledged for three related White Tern pairs in Kapiolani Park, Oahu, Hawaii, from June 1978 to December 1984.

Year	Date Egg	Interval (months)	Date Egg	Interval (months)	Date Egg	Interval (months)	TOTAL Eggs	TOTAL Chicks
PAIR 1								
1978	8 Jun	8					1	0
1979	16 Feb	5	11 Jul	7			2	2
1980	24 Feb	4	3 Jul	4			2	2
1981	16 Jan	5	2 Jun	5	28 Oct	5	3	3
1982	27 Mar	10					1	0
1983	11 Jan	5	29 May	7	23 Dec	5	3	3
1984	16 May	7	22 Dec				2	1
						Total	14	11
PAIR 2								
1981	26 Feb	5	21 Jul	7			2	2
1982	2 Mar	12					1	1
1983	14 Mar	16					1	0
1984	23 Jul						1	1
						Total	5	4
PAIR 3								
1981	13 Dec	15					1	
1982								1
1983	13 Mar	8	8 Nov	5			2	2
1984	31 Mar	5	15 Sep				2	2
						Total	5	5
						Grand Total	24	20

breeding pattern from an annual cycle to a short cycle between 1982 and 1984. Two of these pairs hatched second eggs in December 1983 after rearing chicks and reared three offspring each in 1984, and one of these pairs laid again on 24 December 1984. Of these 12 pairs, 6 bred on a short cycle from their first year of breeding (1979-1984).

Dorward (1963) recorded the intervals between egg-laying for 59 pairs of White Terns. Most (35 pairs) laid at intervals of 11 or 12 months. Of 15 birds banded in the first season, all but 3 returned with the same partner and laid on the same spot in the second season. I recorded intervals of 11 to 15 months between egg-laying for 10 pairs that laid on the same nest site for 2 to 5 years and reared a single chick during each year. This finding is similar to that of Ashmole (1968) and Dorward (1963).

Breeding Success

I compared the breeding success during 5-year periods of two pairs that bred annually (Pair A and Pair B) with that of a pair that bred on a short cycle (Pair 1). These three pairs had been monitored regularly between 1978 and 1984 and supplied the most reliable data over the longest period. Pair 1 reared more than twice the number of offspring as Pair A or Pair B (Table 2).

Intersibling Behavior

Howell (1978) noted that young White Tern chicks were tolerant of any adult bird that came to the nest site; such visitors frequently approached, preened and brooded a small chick. If a parent returned while the visitor was present, it quickly attacked and chased away the intruder.

I observed similar behavior and also feeding of chicks by visiting adults. In August 1979 a 5-day-old chick was visited by its older sibling, a 5-month-old fledgling identified by black underwing coverts. A parent sitting nearby after brooding the chick did not chase off the older sibling during this first visit, but subsequent visits were not tolerated by either parent. In 1980 this same bird, then a juvenile and still showing black underwing coverts, was often observed guarding, occasionally feeding or awkwardly attempting to brood the new chick (its youngest sibling) when the parents were away, but was always chased off when a parent returned.

Howell (1978) found older chicks to be very aggressive toward non-parent adults or juveniles that approached. I found that older chicks—from about 21 days of age to first flight at about 45 days of age—assumed an aggressive posture when a non-parent adult sat near them or attempted to brood them, but not all succeeded in routing the visitor. I also observed an attack on a 46-day-old chick by an adult visitor that was breeding in an adjacent tree. The adult bird grasped the bill of the chick in its bill and twisted it back and forth until the chick fell, resulting in its first flight. I also observed the contrary behavior when a 10-week-old fledgling grasped the bill of an adult visitor that had just fed it a fish and forced the struggling adult off the nest limb.

I have found no data in the literature on the White Tern that describes the ages and behavior of offspring at critical stages of development, nor precise figures on the length of time that parents continue to feed them after they fledge. From 1978 to 1984 I monitored the rearing of 95 chicks of 45 pairs

and found the following in most parents and offspring: both parents fed the offspring on the nest site for the first 45 days, until the chick was 6.5 weeks old and made its first trial flight off the nest limb. The fledgling then picked a perch of its own above the nest if possible. It used its voice for the first time, if needed, to attract a parent with fish to its new location.

After 3 weeks of practice flight in the breeding area, the 10-week-old fledgling flew to sea where it practiced fishing for 3 weeks while the parents

Table 2. A comparison of the breeding success during 5-year periods of two pairs of White Terns that bred annually (Pairs A and B) and one pair that bred at intervals of 5-7 months (Pair 1) in Kapiolani Park, Oahu, Hawaii.

Year	Egg laid	Egg lost*	Chick hatched	Chick lost**	Eggs laid	Chicks fledged	Offspring reared
PAIR A							
1978	May		Jun		1	1	1
1979	Apr		May		1	1	1
1980	Jan		Feb		1	1	1
	Dec				1	0	
1981		Jan			0	0	0
1982	Apr		May	Jun	1	1	0
				Totals	5	4	3
PAIR B							
1979	Aug		Sep		1	1	1
1980	Apr		May		1	1	1
1981	Mar		Apr		1	1	1
1982	Apr		May	Jun	1	0	0
1983	Mar	Apr			1		
	May		Jun		1	1	1
				Totals	6	4	4
PAIR 1							
1979	Feb		Mar				
	Jul		Aug		2	2	2
1980	Feb		Mar				
	Jul		Aug		2	2	2
1981	Jan		Feb				
	Jun		Jul		3	3	3
	Oct		Nov				
1982	Mar	Oct			1	0	0
1983	Jan		Feb				
	May		Jun		3	3	3
	Dec		Jan '84				
				Totals	11	10	10

* Two eggs abandoned due to storm and pigeons; one to egg infertility.
** Fledgling injured in flight; four-week chick vanished; (causes unknown).

continued to feed it. At 13 weeks of age it could feed itself but parents continued to hold fish for it, sometimes for many hours. The independent offspring then picked a new perch or left the area. Offspring were fed for 91 days. Total parental care including incubation required 126 days minimum.

DISCUSSION

White Terns breeding on a "short cycle" produced twice the number of offspring each year as annual breeders. As the population in my study area grew the number of pairs that bred at short intervals increased. When some of the annual breeders changed their breeding pattern to short-cycle breeding, they produced twice the number of offspring they had been producing during their first year or two of breeding.

This unexpected finding suggests that a change may be taking place in the breeding biology of the Oahu White Terns that may not be taking place in the White Terns in other areas. At French Frigate Shoals, for example, environmental changes brought about by human occupation have caused a White Tern population to become established where none existed before 1965 (Rauzon & Kenyon 1984). Also, according to Harrison et al. (1984) the White Tern population on Midway Atoll has greatly increased in the past 50 years due to the introduction of the ironwood (*Casuarina litorea*). This tree provided additional habitat which is relatively unaffected by Black Rats (*Rattus rattus*) introduced in 1943. These environmental changes increased the number of White Terns in these two areas but no change in their annual breeding pattern was noted.

The short intervals between breeding found in the Oahu White Terns appears to be unique to Oahu. Other White Tern populations have not been found to exhibit short-cycle breeding; long-term monitoring is needed to confirm these differences in their breeding biologies.

Oahu may have survival advantages not found in other areas: mild climate, unlimited choice of arboreal nest sites, habitats that allow low-density breeding and the privacy White Terns seem to prefer. Nearby fishing grounds provide a variety and year-round availability of food (Harrison et al. 1983). The occasional feeding of chicks by older siblings may minimize the difficulty of rearing two or three offspring during a year.

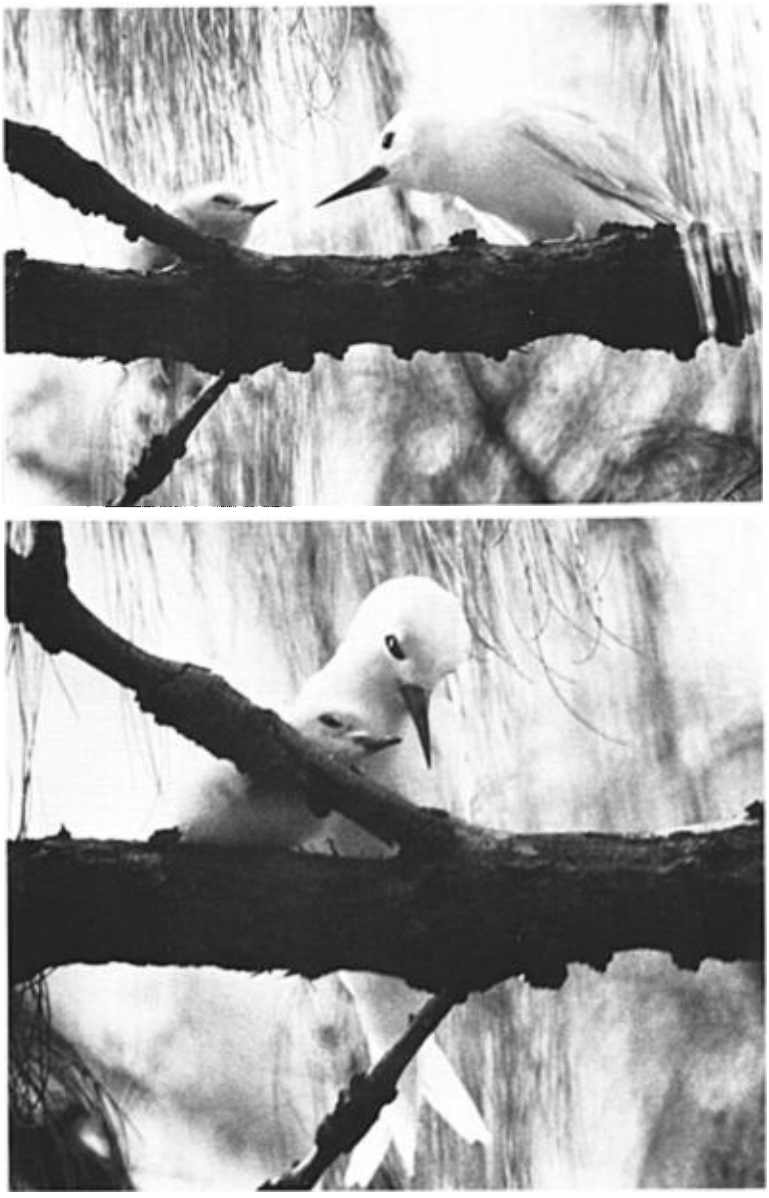
Lack (1968) said, "adaptations of birds to the external environment which affect the number of young raised . . . are closely interrelated and have evolved through natural selection in the natural habitat of the species. Hence findings in habitats much modified by man may be misleading."

A comment by Darwin (1859) regarding inhabitants of oceanic islands may also be food for thought: "Species occasionally arriving after long intervals of time in the new and isolated district, and having to compete with new associates, would be eminently liable to modification, and would often produce groups of modified descendents."

The similarity in the breeding patterns of Pair 1 and four of their offspring strongly suggests a genetic basis for short-cycle breeding in White Terns. However, the apparent behavioral plasticity of some pairs switching from annual to short-cycle breeding leaves this question open for further research.

Figure 1. Two-week-old first chick of Pair 1, 3 April 1979, on nest site in *Casuarina* tree where previous egg was laid in June 1978.

Figure 2. Seventh chick of Pair 1—a day-old ball of fluff—in the small fork of the *Casuarina* tree where eight eggs were laid previously. The bird on the right is side-stepping away to let her mate take his turn brooding the chick. Photo taken 3 December 1981.



Figures 3 and 4. Typical postures of a White Tern visitor before it attempts to brood a young chick. This chick is 1 week old. An older chick would display a defensive posture—leaning forward with bill open—and resist the approach of any visitor except its parents. Photos taken 9 December 1981.

Figure 5. This rare photo of Pair 1 parent and two 1979 siblings shows the 5-month-old sibling—identified by black underwing coverts—visiting the new chick on 20 August 1979. It was not chased off as it was in subsequent visits.

Photos by Dorothy H. Miles

ACKNOWLEDGMENTS

Barbara Macaulay showed me a young White Tern in a Kiawe tree in July 1975. The parents returned to the same nest site in 1976 and became the first breeding pair in my study. Her report of this pair was published in the Hawaii Audubon Journal (Macaulay 1976). Kim and Teruo Sasaki, Kay Ahearn, Pat Purcell, Venona Honchell and many others to whom I owe my gratitude have reported valuable information to me over the years. I am especially grateful to Barbara B. DeWolfe who first made me aware of the value of my work and urged me to band the birds and publish my findings. Banding, care and replacement of fallen chicks, medical treatment and autopsies were made possible through the cooperative efforts of the Hawaii Division of Forestry and Wildlife, the Honolulu Zoo, the Honolulu Fire Department Unit 7, and the Department of Parks and Recreation, with special thanks to Ron Walker, Tim Burr, Tim Sutterfield, Marie Morin, Peter Luscomb, Margo Lengen, Keo Tenjoma, Bob Miyashita and Steve Salis; and to Drs. Eric Ako and R.W. Steckelberg for veterinary services. I also thank the U.S. Fish and Wildlife Service, the Zoology and Science departments of the University of Hawaii and all who generously supplied information and references including G.C. Whittow, C.J. Ralph, Maura Naughton and Carl Fieber. For their help and advice on the first drafts of this paper I am indebted to Andrew J. Berger, Ronald Walker, Marie Morin and Marion Steinhauser, and for later drafts, Sheila Conant, Craig Harrison and Leonard Freed.

LITERATURE CITED

Ashmole, N.P. 1968. Breeding and molt in the White Tern (*Gygis alba*) on Christmas Island, Pacific Ocean. Condor 70:35-55.

Berger, A.J. 1981. Hawaiian birdlife. 2nd ed. Univ. Press Hawaii, Honolulu.

Darwin, C.R. 1859. The origin of species. John Murray, London.

Dorward, D.F. 1963. The Fairy Tern (*Gygis alba*) on Ascension Island. Ibis 103b:365.

Harrison, C.S., M.B. Naughton & S.I. Fefer. 1984. The status and conservation of seabirds in the Hawaiian Archipelago and Johnston Atoll. *In* J.P. Croxall, R.W. Schreiber & P. Evans, eds., Status and conservation of the world's seabirds. ICBP Tech. Publ. #2.

Harrison, C.S., T.S. Hida & M.P. Seki. 1983. Hawaiian seabird feeding ecology. Wildl. Monogr. 85.

Howell, T. 1978. Ecology and reproductive biology in the White or Fairy Tern (*Gygis alba*). *In* Ecology and reproductive behavior of the Gray Gull and of the Red-tailed Tropic Bird and the White Tern on Midway Island. Natl. Geogr. Soc. Res. Rep. Vol. 10:274-284.

Lack, D. 1968. Ecological adaptations for breeding in birds. Methuen & Co., London.

Macaulay, B. 1976. Field notes. Elepaio 36:139-140.

Moynihan, M.H. 1962. Hostile and sexual behavior patterns of South American & Pacific laridae. Behavior (Suppl.) 8.

Ord, M.W. 1961. White Terns at Koko Head, Oahu. Elepaio 22:17-18.

Pettit, T.N., G.S. Grant, G.C. Whittow, H. Rahn & C.V. Paganelli. 1981. Respiratory and gas exchange and growth of White Tern (*Gygis alba*) embryos. Condor 83:355-361.

Rauzon, M.J. & K.W. Kenyon. 1984. White Tern nest sites in altered habitat. Elepaio 44:79-80.

Accepted 17 January 1985

ADDENDUM

This report updates my continuing study to July 1985 and presents new evidence that attacks on chicks by adult or juvenile visitors appear to be pre-copulatory behavior and can limit the number of offspring reared (e.g., Pair 2, Table 1).

Twenty-four pairs were monitored. Five new pairs reared three chicks. Nine returned annual breeders reared six chicks, lost one, and were incubating one. A pair that lost their chick last year (the attackers of chicks of Pair 1 and Pair 2 since 1982) had not yet laid. Ten pairs of short-cycle breeders had produced 13 chicks by mid-July, including 3 sets of siblings. (Of 12 pairs, 2 had lost their nest limb due to tree-trimming in 1981 and 1984.) The three focal pairs (Table 1) increased their total production from 20 to 24 offspring. The failure of Pair 2 to produce a sibling in 1982 and the loss of their first egg in 1983 and first chick in 1984 can be attributed to hostile attacks by a pair that had usurped their night perch. One of this pair seemed determined to throw their chick off the nest and take over the nest site. I had seen this behavior in unmated juvenile siblings since 1980, but never the take-over of a perch by an intruder. I had observed attacks by this pair in 1983 and 1984. From 4 May to 20 May 1985, I watched them daily attacking the 3-week old chick of Pair 2. It was finally wrestled to the ground, but rescued. Both parents aggressively chased them, but attacks continued until courting and copulation began, after which a benign visit was made to the chick and they left the area, apparently to find a new nest site.